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The Impact of Childhood Maltreatment on Cerebellar Volume

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The Impact of Childhood Maltreatment on Cerebellar Volume

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Abstract

The Impact of Childhood Maltreatment on Cerebellar Volume

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The purpose of the current study is to investigate the relationship between expusre to childhood maltreatment and the development of the cerebellar vermis and cerebrocerebellum. Reduced volumes in certain brian structures have been discovered in childhood maltreatment survivors, including the amygdala, hippocampus, and corpus callosum (Bremmer, et al., 1997; De Bellis, et al., 1999; Jackowski, et al., 2007; Teicher, et al., 2003; Teicher, et al., 2012). Furthermore, a number of studies have examined the impact of childhood abuse on cerebellar volume, suggesting that the cerebellum is susceptible to the effects of early stress (Anderson, et al., 2002; Bauer, et al., 2009; Beers & De Bellis, 2002; Carrion, et al., 2009; De Bellis & Kuchibhatla, 2006).

However, few studies have examined the relation between type, frequency, and timing of maltreatment and cerebellar volume. Previous studies have addressed some of these questions, but had small sample sizes and were focused on different structures of the brain (rBRemmer, et al., 1997; De Bellis, et al., 1999). The current study proposes to

examine cerebllar volume in relation to type, frequency, and timing of maltreatment with a considerably large sample size. It is hypothesized that there will be a significant relation between type, frequency, and timing of maltreatment and cerebellar volume. As the impact of maltreatment and development of the brain is still not fully understood, the current study seeks to contribute to the neuropsychological understanding of maltreatment and possibly shed light on potential treatment implications.

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Chapter One: Introduction

Child abuse is a persistent problem in our society that causes long-term negative consequences to child and adolescent trauma survivors. The frequency of child abuse and its longitudinal consequences are national problems that warrant further research and understanding. Previous research indicates that almost 50 percent of the United States population retrospectively reports experiencing some form of maltreatment in childhood (Dong, et al., 2004). In 2012, about 3.5 million reports of child abuse were made, with neglect reported as the most common form of maltreatment. About one-third of children abused or neglected are under the age of 3 (U.S. Department of Health and Human Services, 2013). Younger children are also more likely to be re-exposed to maltreatment (Levy, et al., 1995). While the rate of maltreatment varies across cultures (i.e. White and African American children experience more maltreatment), research indicates that maltreatment is one of the few life experiences that cuts across race, ethnicity, religion, education levels, and socioeconomic status (Child Help, 2012).

However, the prevalence rates of maltreatment are not entirely accurate, due to the uncertainly and ambiguity surrounding maltreatment categories and how they are defined. There are a number of barriers, including legal issues, lack of standardization of definitions, and cultural differences that limit our ability to improve the current operational definition of child maltreatment. Given these limitations, creating a universal list of characteristics is a daunting task. Maltreatment is typically broken down in four categories: physical abuse, sexual abuse, neglect, and emotional or psychological abuse. Recently, researchers have discovered significant emotional and neurological effects in

maltreated children that extend beyond the traditional abuse categories. Thus, the literature is adding more specific and varied categories, enabling researchers to gain a more robust understanding of what maltreatment looks like in the population and how all forms of maltreatment may impact development (Teicher, et al., 2010; Teicher & Vitaliano, 2011).

The theoretical framework utilized by many researchers to conceptualize the impact of childhood maltreatment is the ecological-translational model which takes into account the interactive child-environment relationship through a developmental framework. The ecological-translational model views child maltreatment as an insult outside the realm of the average environment, which alters their developmental trajectory and impacts development and quality of life (Cicchetti & Lynch, 1993). In the past, the changes and outcomes that resulted from maltreatment exposure were viewed as negative or maladaptive. However, there has been a shift in this perspective, which conceptualizes maltreatment outcomes as adaptive changes that allow the child to survive his or her circumstances.

Overall, experiencing any type of maltreatment has been found to be associated with a host of negative outcomes, emerging as early as the first few months of life and persisting into adulthood (Camras, et al., 1996; Hussey, Chang, & Kotch, 2006). In a more recent review, Wilson, Hansen, and Li (2011) presented a cohesive meta-analysis of the cognitive, emotional, behavioral, and neuropsychological effects of child maltreatment within the framework of the traumatic stress response. Negative outcomes of experiencing childhood maltreatment include, but are not limited to, drug and alcohol

abuse, increased aggression, difficulty processing emotionally-laden and neutral stimuli, lower cognitive abilities, impulsivity, and poor executive functioning (Hussey, Chang, & Kotch, 2006; Perry, 2008; Raskin, 1997; Wilson, Hansen, & Li, 2011).

In addition to cognitive, emotional, and behavioral effects of maltreatment, physiological and biological effects of maltreatment have also been documented. Researchers in the Adverse Childhood Experiences (ACE) study found a strong relationship between experiencing childhood abuse, including household dysfunction, and the leading causes of death in adults, such as sexually transmitted disease, severe obesity, ischemic heart disease, cancer, chronic lung disease, skeletal fractures, and liver disease (Felitti, et al., 1998). Researchers have discovered that as the number of exposures to maltreatment increase, the number of poor health outcomes also increases later in life (Felitti, et al., 1998; Fluke, Yuan, & Edwards, 1999).

Maltreated children are also more likely to develop psychiatric disorders over the course of their lifetime, including major depression (Anda, et al., 2002; Danese, et al., 2009; Green, et al., 2010; Scott, Smith, & Ellis, 2010; Widom, DuMont, & Czaja, 2007), bipolar disorder (Anda, et al., 2007), anxiety disorders (Cougle, et al., 2010; Green, et al., 2010; Scott, Smith, & Ellis, 2010), posttraumatic stress disorder (Green, et al., 2010; Scott, Smith, & Ellis, 2010), substance abuse (Dube, et al., 2003; Kendler, et al., 2000; Scott, Smith, &Ellis, 2010), personality disorders (Herman, Perry, & van der Kolk, 1989; Zanarini, et al., 1997), and psychoses (Cutajar, et al., 2010). Furthermore, research suggests that the psychopathology of maltreatment survivors different greatly from other individuals with similar diagnoses (Teicher & Samson, 2013). Overall, maltreated

individuals with psychiatric diagnoses experience disorders that surface earlier, with greater severity, more comorbidity, and poorer response to treatment, compared to their non-maltreated peers (Alvarez, et al., 2011; Leverich, et al., 2002; Nanni, Uher, & Danese, 2012).

Adults who experienced childhood maltreatment continue to struggle with many of the psychological issues mentioned previously. In addition to those cognitive issues, adult survivors of abuse have also been documented to exhibit poorer executive functioning (Raskin, 1997), deficits on attention based tasks (Vasterling, et al., 2002), and are more likely to endorse serious health issues, such as suicide, obesity, and alcoholism, that are considered to be risk factors for several of the leading causing of death in adults (Felitti, et al., 1998).

Childhood maltreatment also impacts developing brain structures, function, and organization. Traditionally, researchers have examined the neurological impact of child maltreatment in the limbic system, specifically the hippocampus and the amygdala (Bremner, et al., 1997; Bremner, et al., 2003; Driessen, et al., 2000; Stein, 1997; Teicher, et al, 1993), the corpus callosum, and the prefrontal cortex (Cohen, et al., 2002; De Bellis, et al., 1999; Reichert, Carrion, Karchemshkiy, & Reiss, 2006; Teicher, et al., 1997). Neurotransmitter dysregulation and impairment in nervous system functioning have also been found to correlate with early childhood maltreatment exposure (Kaufman & Charney, 2001; McEwen, 1998; Repetti, et al., 2002).

Some studies have examined the cerebellar vermis and have discovered a reduction in the cerebellar vermis as a result of maltreatment exposure (Carrion, et al., 2009;

DeBellis & Kuchibhatla, 2006). The cerebellum has traditionally thought to be the center of motor coordination in the brain, and therefore was not been viewed as an area of much interest particularly in the maltreatment literature. However, as our understanding of the brain grows and evolves, so has the role of the cerebellum has changed. Research suggests that the cerebellum is involved not only in motor coordination, but also in multiple cognitive and executive functioning tasks (Allen, Buxton, Wong, & Courchesne, 1997; Allen & Courchesne, 2003; O'Reilly et al., 2010).

One possible explanation for the numerous roles of the cerebellum is that it projects to multiple subdivisions of the ventrolateral thalamus, which then project to a multitude of cortical areas, including frontal, prefrontal, and posterior parietal cortex regions (Jones, 1985; Schamahmann, 1996; Strick, Dum, & Fiez, 2009). In particular, the posterior cerebellum shares functional connections to the prefrontal and posterior parietal areas of the brain, which are involved in attention, emotional regulation, and planning (Allen et al., 2005; Barlow, 2002; O'Reilly et al., 2010). Therefore, abnormality in the communication among these areas could result in motor deficits, as well as cognitive, affective, and attentional impairments (Strick, Dum, & Fiez, 2009). Furthermore, new data suggests that abnormalities in the cerebellar vermis play a role in a multitude of psychiatric disorders such as attention deficit hyperactivity disorder (ADHD) (Berquin, et al., 1998; Castellanos, et al., 2001; Mostofsky, et al., 1998), autism (Courchesne, 1991; Levitt, et al., 1999; Townsend, et al., 2001), schizophrenia (Andreasen, et al., 1998), and depression (Fischler, et al., 1996; Lauterbach, 1996; Loeber, et al., 1999; Sweeney, et al., 1998), some of which are commonly associated with maltreatment exposure.

Specific to the maltreatment exposure, the cerebellum has been implicated in postmortem animal studies in which the animals experienced neglect (Harlow, Dodsworth, & Harlow, 1965; Harlow & Harlow, 1966; Prescott, 1980). Rodents raised in isolation exhibited deficits in cerebellar metabolism and ability to inhibit the release of certain neurotransmitters (Essman, 1968; Miachon, et al., 1990), as well as delayed development of cerebellar dendrites (Rogers, 1989). Harlow's monkeys reared in social isolation exhibited smaller vermal volumes and aggressive behavior. Harlow's (1966) research was one of the first studies conducted to shed light on the role of the cerebellar vermis in emotional development. The results of these animal studies suggest that the cerebellar vermis is an important region for the maintenance of psychiatric health. They also suggest that the vermis is significantly affected by early stress or neglect, and may have the capacity to reduce or mediate some of the neurological and behavioral consequences of early stress or neglect (Teicher, et al., 2003).

Given the cerebellum's level of connectivity, vulnerability to environmental influences, and the extensive animal research conducted, the maltreatment literature is beginning to examine the impact of maltreatment exposure on the development of the human cerebellum. De Bellis and Kuchibhatla (2006) were the first to examine cerebellar morphology in adult and child PTSD in maltreated subjects using structural imaging. They examined the cerebellar volume of pediatric victims of maltreatment, suffering from PTSD compared to a non-affected group of children. There were significant group differences in the unadjusted means of the volumetric measures in the right cerebellum, left cerebellum, and whole cerebellum. In comparison to the healthy

comparison group, the intracranial volume was 6% and total cerebellar volume was 7% smaller in the PTSD group. De Bellis and Kuchibhatla (2006) discovered that the longer the child experienced trauma, the smaller the cerebellar volume. Age of onset was also found to be positively correlated with cerebellar volume. However, the study was limited due to the sole inclusion of maltreated participants with PTSD, which clouds the interpretation since it is unclear if the results were related to maltreatment exposure or PTSD diagnosis.

Carrion and colleagues (2009) conducted a prospective study and discovered that children with PTSD had significantly smaller gray matter volume in the posterior vermis, compared to typical peers. However, the study's inclusion of the vermis was more exploratory and did not go into as much depth of analysis as compared to the study's primary regions of interest. Carrion and colleagues (2009) acknowledged that the study was potentially negatively impacted by its cross-sectional design, the lack of ethnicity and SES matching, as well as only including participants with PTSD.

Bauer and colleagues (2009) studied children raised in orphanages and examined the impact of early deprivation on cerebellar volume and cognitive functioning, discovering that neglected children had smaller volumes of the superior-posterior cerebellar lobes. Furthermore, the superior-posterior cerebellar regions were found to mediate some cognitive processing, specifically planning and visual-spatial memory (Bauer, et al., 2009). The findings suggest an important role of experience-dependent plasticity in the brain-behavior relationship supported by the cerebellum. The fact that postinstitutionalized children demonstrate smaller cerebellar volumes and worse

cognitive performance than typically developing subjects suggests that physiological and social deprivation have a profound influence on cerebellar neurodevelopment. Deprivation serves as an environmental stressor that might disrupt early cerebellar organization and maturation and consequently lead to underdeveloped neural pathways between cerebellum and cortex (Bauer, et al., 2009).

Furthermore, researchers have explored multiple variables that may increase or decrease the impact of maltreatment, including gender and age of the maltreatment experience. Research indicates that certain types of maltreatment seem to impact genders differently. An emerging literature is focusing on the idea of "windows of vulnerability," examining the potential protective factor of age of exposure to maltreatment (Pechtel, et al., 2014). In a longitudinal MRI cerebellum study, Tiemeier and colleagues (2010) discovered that total cerebellum developed along an inverted U shaped trajectory, which peaked at 11.8 years in females and 15.6 years in males. Furthermore, they found the certain subdivisions of the cerebellum had distinctive developmental trajectory with more phylogenetically recent regions maturing later (Tiemeier, et al., 2010). They also discovered a gender difference in developmental trajectory, particularly in the superior posterior lobe (Tiemeier, et al., 2010). Thus indicating the potential for significant finding based on age of exposure of maltreatment and stage of cerebellar development. While the literature on child maltreatment has grown and the quality of research studies has greatly increased, many unanswered questions remain.

In summary, the cerebellum is one of the first structures to develop (Schmahmann, 1996), has been found to connect with multiple areas of the brain, and

continues to develop well into adolescence, thus resulting in a period of prolonged vulnerability during childhood (Tiemeier, et al., 2010). Given the cerebellum's level of connectivity and previous research that has implicated the cerebellum in maltreatment, understanding the impact of maltreatment on the development of the cerebellum is imperative. It is especially important since altering the developmental trajectory of the cerebellum could have diffuse negative effects throughout the brain over the course of development.

The current study proposes to continue the research of childhood maltreatment and the cerebellum while focusing on a region of the cerebellum that is gaining interest in the maltreatment literature, the posterior cerebellar hemisphere. The influence of the type of maltreatment experienced, the frequency of exposure to maltreatment, and the timing or age of exposure will also be analyzed. Cerebellar vermis volume and cerebrocerebellum volume will be examined through a large-scale retrospective study, with a total of 600 MRI scans of maltreated and non-affected young adults. The current study predicts cerebellar volume of the maltreated group will differ from the non-affected group, repeated exposure to maltreatment will result in smaller cerebellar volume, and different types of maltreatment will have differential effects on cerebellar volume. The current study also predicts that the cerebellum undergoes a sensitive period or "window of vulnerability," in which cerebellar volume is more susceptible to the negative effects of maltreatment.

The current study will focus on the vermis and the posterolateral neocerebellar hemispheres (Cerebrocerebellum). The cerebellar vermis will be an area of focus due to

its connections to the limbic system (Snider & Maiti, 1976). Since the limbic system has been reported to be negatively affected by maltreatment, it is hypothesized that this impact will be reflected in the cerebellar vermis, given the high level of connectivity between the two structures. It is also hypothesized that the vermis is one of the first areas of the brain to be negatively impacted, given that it undergoes the greatest increase in size of any brain region in the postnatal period (Giedd, et al., 1999) and has the highest density of glucocorticoid receptors (exceeding the hippocampus in the limbic system) (Lawson, et al., 1992). These postnatal developmental aspects of the vermis could make it fairly vulnerable to the effects of stress hormones (Ferguson & Holson, 1999; Schapiro, 1971).

The proposed study will also focus on the cerebrocerebellum, which links the cerebellum to higher-order regions in the brain (Schmahmann, 1996). The posterior regions of the cerebellum are of particular interest, since they are involved in cognitive and executive functioning. Given that children who experience maltreatment suffer from deficits in executive functioning and cognitive skills, (Watts-English, et al., 2006; Wilson, Hansen, & Li, 2011), it is hypothesized that maltreatment impacts the cerebrocerebellum, which then impacts cognitive and executive functioning.

This study will also attempt to expand the existing literature by examining potential sensitive periods of both the vermis and cerebrocerebellum. Given the cerebellum's unique developmental trajectories and particular vulnerability to environmental influences, the potential for negative effects of maltreatment is large.

Both the focus on unique areas within the cerebellum and the focus on timing of exposure will contribute new information to the maltreatment literature.

In the past, the generalizability of maltreatment research has been somewhat limited. In order to maintain statistical power, researchers are often forced to create arbitrary groupings of maltreatment time and age of exposure. This allows for statistical analysis, however does not generalize to the general population. The statistical analysis that will be employed for this study (random forest regression) will allow for exposure of maltreatment and type of maltreatment experience to be examined along a continuum. Random forest regression allows for more variables to be studied, while maintaining statistical power, thus ensuring the results are more generalizable. This research would help the field gain better insight into how maltreatment affects children, specifically in the development of the cerebellum as well as specific regions within the cerebellum. Furthermore, by broadening our knowledge of which brain structures are implicated in child maltreatment, researchers may be able to help inform future intervention, identify key ages for intervention, and help therapists better conceptualize and treat maltreated clients.

Chapter Two: Literature Review

The following integrative analysis provides a theoretical rationale for the possible relationship between maltreatment and cerebellar vermis volume and cerebrocerebellum volume. It is hypothesized that individuals who have experienced maltreatment have reduced cerebellar volume compared to the cerebellar volume of their non-affected peers. To provide support for this hypothesis, an overview of the literature on cerebellar abnormalities in animals and humans who have experienced maltreatment, the effects of maltreatment over the course of development, and brain imaging research examining the impact of maltreatment on various brain structures will be presented. This integrative analysis begins with an overview of the prevalence rates of maltreatment, categories of maltreatment, the limitations of those categories, and a developmental conceptualization of maltreatment. Next, literature on the psychological and neurobiological outcomes of maltreatment are presented. Finally, a review of the cerebellum and cerebellar abnormalities in maltreatment is presented to establish the importance of examining the cerebellum within maltreatment.

Child Maltreatment

Prevalence rates of maltreatment. The United States Department of Health and Human Services (2013) reported that there are an estimate of 3 to 3.6 million reports of child abuse are made in the United States annually. Of those reports, about 686,000 unique victims of abuse and neglect were estimated, resulting in a rate of 9.2 victims per 1,000 children in the United States. More than one quarter (26.8%) of maltreatment victims were younger than 3 years of age, while 20% of victims were in the age group of

3-5 years (U.S. Department of Health and Human Services, 2013). Males and females experienced maltreatment equally. 44% of maltreated children were White, 21.8% of Hispanic background, and 21% were African American. However, victims of African American, American Indian or Alaska Native, or multi-racial descent had the highest rates of maltreatment exposure.

The majority of children experience neglect (78.6%); 18.3% experience physical abuse, 9.3% experience sexual abuse, and 10.6% experience "other" types of maltreatment. (U.S. Department of Health and Human Services, 2013). Victims between 0 and 2 years of age experienced the largest percentages of exposure across all maltreatment types, with the exception of sexual abuse. Females ages 12-14 experienced 26.3% of sexual abuse, while 33.8% percent of sexual abuse victims were younger than 9 years of age (U.S. Department of Health and Human Services, 2013).

In 2010, the United States is reported to lose more than five children a day to abuse (Of those five children 80% are under the age of 4), the worst record in any industrialized nation (U.S Department of Health and Human Services, 2010; United States Government Accountability Office, 2011). In the federal fiscal year (FFY) 2012, it was estimated that 1,640 children died from abuse and neglect, at a rate of 2.20 per 100,000 children in the United States (U.S. Department of Health and Human Services, 2013). Children younger than 3 years account for 70.3% of all child fatalities, with children younger than 1 year dying at a rate of 18.83 per 100,000 children. This rate is three times the rate of children who were 1 year old. While the rate of maltreatment-related child fatalities was lower in 2012 compared to 2008, both the number of rate of

fatalities have been increasing since 2010, due to the passage of the Child and Family Service Improvement and Innovation Act (P.L. 112-34) which has improved reporting (U.S. Department of Health and Human Services, 2013).

The National Longitudinal Study of Adolescent Health retrospectively measured child maltreatment of 15,197 young adults in 2001-2002 (Urdy, 2003); results indicated that 41.5% of respondents reported experiencing neglect, 28.4% physical assault, 11.8% physical neglect, and 4.5% sexual abuse. Experience of any type of maltreatment was found to correlate with at least 8 adolescent negative health outcomes, including but not limited to, poor health, depression, increased violent behavior, and obesity (Hussey, Chang, & Kotch, 2006). Other research results indicated that 13.8% of children are exposed to one or more types of maltreatment, while retrospective studies estimate 42% of the population has experienced some type of abuse in the first eighteen years of childhood (Dong, et al., 2004). Research suggests that adults who retrospectively report their exposure to maltreatment tend to underreport their experiences, indicating that rates may actually be higher than 42% (Shaffer, Huston, & Egeland, 2008; Williams, 1994). Thus, while the rates of maltreatment vary across studies, it is apparent that maltreatment affects at least half of the population in the United States.

While there are a number of questionnaires used to collect data on the rates of maltreatment, prevalence rates of maltreatment are hypothesized to be lower than the true occurrence of maltreatment in the population. There are many limitations within the collection of maltreatment information, due to how the information is collected and the fact that most research in this area has predominantly retrospective and focused on

individuals who are white. Even with these limitations, the research strongly suggests that child abuse occurs at every socioeconomic level, across ethnic and cultural lines, within all religions and at all levels of education (Child Help, 2012).

Recurrence of maltreatment. Recurrence has been conceptualized as any subsequent report of maltreatment (Baird, 1988; English, 1989); any subsequent founded or verified report of maltreatment (Zunder, 1989); any subsequent maltreatment of the same child; or even recurrence of maltreatment without a prior report; or any combination of these definitions (Fluke, Yuan, & Edwards, 1999). While some researchers consider this definition to be too broad, narrower definitions do not enable the field to cast a wide enough net to capture the recurrence population. Often many discrepancies in the understanding of recurrence emerge due to the variability of social service follow-up meetings (e.g. if a follow-up meeting occurs after an initial report or visit, the depth of the follow-up meeting, the services given at follow-up meetings).

Thus far, researchers have found that children ages 16 and older are less likely to experience the recurrence of abuse, indicating that recurrence is more likely to occur with younger children. Neglect is most often linked with recurrence, with physical abuse and sexual abuse decreasing in recurrence (Fluke, Yuan, & Edwards, 1999). After each subsequent maltreatment event, the likelihood of recurrence also increases. Researchers has also found that African Americans and Whites share similar rates of recurrence, although in some states it has been documented that recurrence tends to happen more to White children then African American children (Levy, et al., 1995; Fluke, Yuan, & Edwards, 1999). It also appears as though Asian/Pacific Islanders experience recurrence

at lower rates compared to other races (Fluke, Yuan, & Edwards, 1999). More disturbing is the discovery that the rate of recurrence is found to increase after the provision of post-investigative services. This means that after social services like Child Protective Services, visit families in which the children have experienced abuse and provide information or services, recurrence of abuse still takes place (Fluke, Yuan, & Edwards, 1999). This finding indicates that the social services that are in place to protect children and reduce or eliminate maltreatment are not effective and may actually cause more harm to the children.

Categories and definitions. In general, there are about 4 to 10 different categories of maltreatment, however there is no single agreed upon definition of maltreatment or types of abuse. In fact, each state is open to create its own definition (Child Welfare Information Gateway, 2006). This causes confusion and ambiguity in our society's understanding of maltreatment, what it is, and what it looks like. This area would benefit from clarity, yet is woefully devoid of any consistency across states and cultures. While there is no agreed upon definition of maltreatment, in the literature, maltreatment is typically broken down in four categories: physical abuse, sexual abuse, neglect, and emotional or psychological abuse.

Generally, physical abuse is recognized as inflicting bodily injury on a minor by nonaccidental means (Cicchetti & Toth, 2005). Bodily injury can range from minor bruises to severe fractures, or in extreme cases death (Child Welfare Information Gateway, 2006). Sexual abuse is defined as sexual contact or attempted contact between a child and an adult for the purposes of the adult's sexual gratification or financial gain

(Cicchetti & Toth, 2005). Neglect is considered to be present when the caregivers provide less than minimum care and a lack of supervision to the child. Lastly, emotional abuse is thought to involve persistent and extreme thwarting (i.e. threats, rejection, withholding of love) of a child's basic emotional needs (Barnett, et al., 1993; Child Welfare Information Gateway, 2006). Emotional abuse is often the most difficult to prove which makes it challenging for social agencies to take action, although emotional abuse has been linked with negative outcomes (Child Welfare Information Gateway, 2006).

The utilization of four categories of abuse has typically been to gold standard in the maltreatment literature, since they were the easiest to identify and assess. Indeed, some of the most frequently used maltreatment measures only assess for sexual abuse, physical abuse, neglect, and emotional abuse. However, the maltreatment literature has begun to expand beyond four categories of maltreatment, recognizing that there are many forms of maltreatment not being accounted for and studied. For example, the Maltreatment and Abuse Chronology of Exposure scale (MACE; Teicher & Parigger, unpublished), distinguishes between parental verbal and non-verbal abuse, and includes witnessing intra-parental physical violence and violence towards siblings, as well as categorizing for various forms of peer abuse and neglect.

Indeed, research suggests exposure to peer abuse is associated with an increase in psychiatric symptoms, as well as corpus callosum abnormalities (Teicher, et al., 2010). Witnessing violence towards siblings has been associated with significant increases in depression, anxiety, and limbic irritability rating scales (Teicher & Vitaliano, 2011). Parental verbal aggression has been associated with increased levels of depression,

anxiety, and drug use, and cannot be easily reduced or reversed by praise from the parent (Polcari, et al., 2014). Given the significant effects found beyond the traditional abuse categories, the addition of more specific and varied categories enables researchers to gain a more robust understanding of what maltreatment looks like in the population and how it may impact development.

Definition limitations. There are a number of barriers, including legal issues, lack of standardization of definitions, and general disagreement that limit our ability to achieve an improved operational definition of child maltreatment. Consensus on a maltreatment definition is difficult to reach due to the fact that maltreatment is a legal matter that is primarily defined by social service systems like Child Protective Services (CPS), who use maltreatment definitions to enforce laws that protect children's rights. Researchers do not have much input in the definition of maltreatment, making research in this area difficult (Cicchetti & Toth, 2005). Moreover, there is not a standardized division between what is considered appropriate parental discipline and what breaches into child maltreatment, contributing to the difficulty in reaching a consensus on a maltreatment definition (Cicchetti & Lynch, 1995). Disagreement also arises around whether child maltreatment should be defined according to the effects on the child or the action(s) of the perpetrator, or if parental intent should be included (Barnett, et al., 1993, McGee & Wolfe, 1991).

There are also multicultural differences, such as parenting practices and expectations that need to be taken into account when conceptualizing maltreatment. While there is generally a cross-cultural agreement in the rights of children to live in safe

environments (United Nations Convention of the Rights of the Child, 1989), in many cultures it is acceptable or expected that one should raise voices at, shame, or hit children. Given the variability of parenting practices across cultures, and within cultures over time, adopting a universal list of characteristics can be extremely difficult. Researchers must be cognizant of these limitations. Slep and colleagues (2011) encourage researchers to utilize an "act plus impact" framework, which considers the maltreatment act in combination with the emotional impact the child takes away from the experience. An "act plus impact" framework for all forms of abuse can incorporate culturally different definitions of maltreatment, while ensuring children are protected (Slep, et al., 2011).

Conceptualization of maltreatment effects. Traditionally, early research conceptualized child maltreatment as a toxic agent that interfered with the normal development of the brain (Teicher, et al., 2003); however over time, researchers found this framework lacking and have begun to view maltreatment effects as a form of adaptation. As such, researchers have been able to acknowledge that the changes produced by maltreatment are an adaptive change that enables the child to survive his or her experience (Teicher, et al., 2003).

A prime example of the shift from maladaptive to adaptive is the traumatic stress response, which starts with the child's assessment of the threat, activating a host of neurochemical reactions to help the individual respond to the stressor and attempt to regain internal homeostasis (Bevans, et al., 2005). Unlike the regular stress response, the neurochemical surge produced by the traumatic stress response outlives the triggering stressor, which further disrupts homeostasis (Weber & Reynolds, 2004). Thus the brain

is locked into a maladaptive feedback cycle that impacts various structures and functions (Southwick, et al., 2005).

One of the most widely accepted frameworks for understanding the effects of childhood maltreatment is the ecological-translational model. (Wilson, Hansen, & Li, 2011). The ecological-translational model takes into account the interactive child-environment relationship through a developmental framework and views child maltreatment as an insult outside the realm of the average environment (Cicchetti & Lynch, 1993). When children experience maltreatment, their developmental trajectory is altered, resulting in immediate effects on development and overall quality of life (Cicchetti & Lynch, 1993). Increased knowledge and a more adaptive conceptualization would help psychologists to be aware of potential changes in brain development, which would allow them to better serve this population of youth, as well as take into consideration a new framework for conceptualizing child maltreatment.

Effects of Childhood Maltreatment

Experiencing maltreatment in childhood has been documented to result in a multitude of negative outcomes in cognitive abilities, neurotransmitter levels, neurological issues, biological issues, and emotional issues. In fact, research suggests that it is the experience of maltreatment rather than other stressors, such as natural disasters, which consistently presents as the precursor to psychopathology (Arseneault, et al., 2011; Ford & Cloitre, 2009). Negative outcomes have been documented to be present as early as the first years of life and persist into late adulthood. While the research typically links outcomes of maltreatment with all forms of maltreatment, some

researchers have found specific outcomes that correlate with specific types of maltreatment.

Early childhood outcomes. The effects of maltreatment have been discovered to emerge as early as the first few months of life with maltreated children displaying several deficits in their affective processing abilities, such as their ability to recognize expression and understand emotions (Camras, et al., 1996; Cicchetti & Toth, 2005). Physically abused boys who watched angry adult interactions reported more fear than non-abused boys (Cummings, et al., 1994) and 80% of maltreated preschoolers experience high levels of emotional dysregulation in the face of adult anger (Maughan & Cicchetti, 2002). Children who experience maltreatment also have difficulty processing social information (Pollak, et al, 2000) and struggle to selectively attend to threat-related signals (Pollak & Tolley-Schell, 2003). Research has found children as young as five demonstrating hypervigilance to hostile cues and not effectively attending to relevant nonhostile cues (Dodge, et al., 1995).

Often, these affect-regulatory issues can lead to behavioral dysregulation in maltreated children. Toddlers have been found to react to peer distress with atypical affect and behavior, including fear, anger and aggression (Klimes-Dougan & Kistner, 1990). Typically, maltreated children experience elevated levels of aggression, an increased risk for attention deficits, and subclinical levels of dissociation (Shields & Cicchetti, 1998). In addition, about 95% of severely maltreated children develop insecure attachments to others, which have been found to the present in early school years (Carlson, et al. 1989; Crittenden 1988; Lyons-Ruth, et al. 1987, Lynch & Cicchetti,

1991). Development of insecure attachments correlate with the presence of depressive symptoms (Toth & Cicchetti, 1996a). Furthermore, the development of self-system processes can often be altered. Deviations in the self-systems have been present in preschool period, as demonstrated by experiencing less pride and more shame in maltreated girls (Alessandri & Lewis, 1996). Maltreated children experience delays in the development of theory of mind (Cicchetti, et al., 2003), inhibiting their ability to attribute beliefs, desires, intentions, and emotions to others. Maltreated children steal, cheat, and break more rules then their non-affected peers (Koenig et al. 2004).

Middle childhood and adolescent outcomes.

Psychological and physical sequelae. The outcomes that emerge in early childhood remain present and continue to alter the development of maltreated children into adolescence. As maltreated children enter into schools, it becomes apparent that early outcomes of maltreatment adversely affect school experience. For example, maltreated children exhibit less empathy (Macfie, et al. 1999), fewer prosocial and more aggressive behaviors (Shields, Cicchetti, & Ryan. 1994), less internalization of compliance (Koenig, et al. 2000) and higher rates of delinquency (Smith & Thornberry, 1995, Tricket, et al., 2011; Widom, 1989) than do their non-affected peers. Maltreated children experience difficulty in developing and maintaining friendships (Parker & Herrera, 1996), are more likely to cause conflict and stress with their peers (Klimes-Dougan & Kistner, 1990), and tend to bully other children more. This is especially the case with children who have experienced physical or sexual abuse (Shields & Cicchetti, 2001). Furthermore, school age children tend to experience difficulty in school and are at

risk for failure in school (Eckenrode, et al., 1993). Physically abused children were found to struggle with peer adjustment, depression, and self-perception (Okun, et al., 1994). Sexually abused girls struggled with social competence, lower overall academic achievement, and higher levels of anxiety and depressive symptoms (Trickett, et al., 1994).

Overall, maltreated students with insecure maternal attachments experienced lower levels of school functioning (Toth & Cicchetti, 1996b). Maltreated children are underserved in schools, receiving less academic supports than their non-affected peers (Jones, Trudinger, & Crawford, 2004). This finding is shocking, given the fact that maltreated children exhibit more externalizing and internalizing behavior problems and have more academic risk factors compared to non-affected peers (Cicchetti & Toth, 2005). Beyond school issues, adolescents who experienced childhood maltreatment are more likely to have a wide array of health issues. Hussey, Chang, and Kotch (2006) discovered that experiencing any type of maltreatment was associated with at least 8 out of 10 health outcomes. Those outcomes include overall poor health, being overweight, depression, cigarette use, alcohol use, marijuana use, inhalant use, engaging in serious fights, and hurting others.

Neurobiological sequelae. Childhood maltreatment can alter the development and trajectory of the brain, impacting developing brain structures, function, and organization. Maltreated children experience diminished startle responses (Klorman, et al., 2003), which can lead to impairments in sympathetic and parasympathetic nervous system functioning, abnormal levels of cortisol, and dysregulation in neurotransmitter

functioning (Kaufman & Charney 2001; McEwen, 1998; Repetti, et al., 2002). The hippocampus, amygdala, corpus callosum, and cerebellar vermis have all been implicated in childhood maltreatment. The hippocampus and amygdala make up part of the limbic system, which is often considered to be the center for emotional control (Wilson, Hansen, & Li, 2011). Individually, the hippocampus in thought to play a role in encoding and retrieving episodic information (Desgranges, Baron, & Eustache, 1998), while the amygdala seems to play a role in fear conditioning, the control of aggressive, oral, and sexual behaviors (Pinchus & Tucker, 1978), and assigning emotional significance to stimuli (Wilson, Hansen, & Li, 2011). Therefore, it seems fitting that studies have found smaller amygdala and hippocampal volumes in maltreated children, although findings across the literature are inconsistent (Bremmer, et al., 1997; De Bellis, et al., 1999; Teicher, et al., 2003; Teicher, et al, 2012). Reduction of corpus callosum volume has been consistently documented in maltreated children (De Bellis, et al, 1999; Jackowski, et al., 2007; Teicher, et al., 2004). The corpus callosum connects the two hemispheres of the brain. While research on the effect of reduced corpus callosum volume on behavior in children is limited, there are many adult studies that address this issue.

Adult outcomes.

Psychological and physical sequelae. Adults who experienced childhood maltreatment continue to struggle with many of the psychological issues mentioned previously. In addition to those cognitive issues, adult survivors of abuse have also been documented to exhibit poorer executive functioning (Raskin, 1997) and deficits on attention based tasks (Vasterling, et al., 2002). Adults who experienced childhood

maltreatment are also more likely to endorse serious health issues that are considered to be risk factors for several of the leading causing of death in adults (Felitti, et al., 1998). The risk factors for the leading causes of death include substance abuse, alcoholism, smoking, obesity, lack of physical activity, depression, suicide, risky sexual behavior, sexually transmitted diseases, chronic obstructive pulmonary disease, and ischemic heart disease (Felitti, et al., 1998).

Maltreated children are also more likely to develop psychiatric disorders over the course of their lifetime, including major depression (Anda, et al., 2002; Danese, et al., 2009; Green, et al., 2010; Scott, Smith, & Ellis, 2010; Widom, DuMont, & Czaja, 2007), bipolar disorder (Anda, et al., 2007), anxiety disorders (Cougle, et al., 2010; Green, et al., 2010; Scott, Smith, & Ellis, 2010), posttraumatic stress disorder (Green, et al., 2010; Scott, Smith, & Ellis, 2010), substance abuse (Dube, et al., 2003; Kendler, et al., 2000; Scott, Smith, &Ellis, 2010), personality disorders (Herman, Perry, & van der Kolk, 1989; Zanarini, et al., 1997), and psychoses (Cutajar, et al., 2010).

Exposure to one or more maltreatment experiences have been found to account for 54% of the risk fraction for recent episodes of depression (Anda, et al., 2002) and 67% for suicide attempts. Survivors of childhood sexual or physical abuse are 2 to 3.83 times more likely to experience phobias, panic disorders, social anxiety disorders, and generalized anxiety disorder (Cougle, et al., 2010). Exposure to adverse childhood experiences also increases the chances of being prescribed medication to help cope with emerging psychiatric disorders (Anda et al., 2007; Teicher & Samson, 2013). While the relationship between maltreatment and substance abuse can be confounded due to

possible prenatal exposure and substance abuse in the maltreating parents, there is prospective evidence for a causal relationship between physical abuse and early adulthood substance abuse (Huang, et al., 2011; Lo & Cheng, 2007).

Furthermore, research suggests that the psychopathology of maltreatment survivors different greatly from other individuals with similar diagnoses (Teicher & Samson, 2013). Overall, maltreated individuals with psychiatric diagnoses experience disorders that surface earlier, with greater severity, more comorbidity, and poorer response to treatment, compared to their non-maltreated peers (Alvarez, et al., 2011; Leverich, et al., 2002; Nanni, Uher, & Danese, 2012). For example, maltreated individuals who suffer from depression experience more severe mood symptoms, psychotic features, more suicide attempts self-harm, and more comorbidities, especially substance abuse, compared to their non-maltreated peers (Harkness & Wildes, 2002; Matza, et al., 2003; Miniati, et al., 2010; Nanni, et al., 2012). Depressed maltreated individuals also experience more neurovegetative and endogeneous symptoms, compared to their non-affected, depressed peers (Hovens, et al., 2012; Miniati, et al., 2010; Nanni, et al., 2012).

The differences in the psychopathology of an individual who has experienced maltreatment compared to a non-affected individual are so significant, researchers advocate for a unique diagnostic classification that will capture the different psychiatric features present in those that have experienced maltreatment (Teicher & Samson, 2013). Differences in diagnoses and outcomes in maltreated survivors compared to their non-affected peers can likely be attributed in some degree to early stress-induced alterations

in trajectories of brain development (Teicher, Anderson, & Polcari, 2012; Teicher, et al., 2003).

Neurobiological sequelae. As previously mentioned, the hippocampus, amygdala, corpus callosum, and cerebellar vermis have been implicated in adults who experienced maltreatment. Damage or reductions of these areas have been linked to the presence of temporolimbic seizures (Kalviainen, et al., 1997; Salmenpera, et al., 2001). EEG abnormalities may be a significant risk factor for suicide ideation or attempts, as well as assault or destructive behaviors (Struve, 1983; Struve, Klein, & Saraf, 1972). Reduced size of the corpus callosum has been associated with diminished communication between the hemispheres (Teicher, et al., 2000). Reduced corpus callosum results in less communication between the hemispheres and more lateralization of function, which can have important consequences on neurotransmitter projections and behavior, like memory (Andersen, 1989; Arato, et al., 1991; Arato, et al., 1991; Rosen, et al., 1984).

The hypothalamic-pituitary-adrenal (HPA) axis that been implicated in many adult studies. The HPA axis communicates and interacts with the hypothalamus, the pituitary gland, and the adrenal glands (Wilson, Hansen, & Li, 2011). It facilitates brain functioning by increasing arousal, alertness, attention, and readiness (Vermetten & Bremner, 2002a; Vermetten & Bremner, 2002b). Chronic hyperactivity of the HPA axis (i.e., hypercortisolism) may lead to the accelerated loss or metabolism of hippocampal neurons, the inhibition of generation of neurons, lags in the development of myelination, abnormalities in synaptic pruning, and impaired affective and cognitive ability (Sapolsky, 1992).

Reduction in cerebellar vermis has also been documented in the maltreatment literature. Furthermore, new data suggests that abnormalities in the cerebellar vermis play a role in a multitude of psychiatric disorders such as attention deficit hyperactivity disorder (ADHD) (Berquin, et al., 1998; Castellanos, et al., 2001; Mostofsky, et al., 1998), autism (Courchesne, 1991; Levitt, et al., 1999; Townsend, et al., 2001), schizophrenia (Andreasen, et al., 1998), and depression (Fischler, et al., 1996; Lauterbach, 1996; Loeber, et al., 1999; Sweeney, et al., 1998). Many of these disorders are experienced by adults that survived childhood maltreatment (Cicchetti & Toth, 2005; Farmularo, et al., 1992).

Effects of Type, Frequency, and Age of Maltreatment

There are various theories that attempt to explain why there is such a host of potential outcomes when exposed to childhood maltreatment, the simplest theory postulates that maltreatment is a general, intensifying factor that increases the chances of "activating" an individual with a genetic risk for a disorder (Teicher & Samson, 2013). While this theory provides some explanation for the higher rates of psychiatric disorders and comorbidities, it fails to incorporate a significant amount of the maltreatment literature.

A more comprehensive explanation for the numerous maltreatment outcomes takes into account hereditary factors, as well as the type, frequency, and timing of maltreatment exposure in a child's developmental trajectory. Following the ecological-translational framework for understanding childhood maltreatment, this theory postulates that exposure to maltreatment ignites modifications to a person's stress-response system and

neurotrophic factors, altering the individual's brain development in an attempt to survive (Teicher & Samson, 2013). The results from ACES study paint a compelling picture, suggesting that increased exposure to maltreatment results in poorer and poorer mental and physical outcomes (Felitti, et al., 1998).

The literature is beginning to explore the concept of sensitive periods, in which brain regions are more susceptible or more resilient to the effects of stress. Pechtel and colleagues (2014) conducted a study that examined possible sensitive periods in amygdala development. Results indicate that exposure to maltreatment between 10 and 11 years of age was the most important predictor of right amygdala volume and was most impactful than overall childhood exposure (Pechtel, et al., 2014). Pechtel and colleagues (2014) also discovered that exposure to maltreatment at ages 7 and 14 was the most important predictor of hippocampal volume. Therefore, it seems that over the course of development there are specific "windows of vulnerability" (Teicher & Samson, 2013, p. 1121) that determine the negative effects of exposure.

The Cerebellum

Cerebellar anatomy. The cerebellum is a highly compact structure, located at the back of the brain. It contains a surface area that is approximately equal to one whole cerebral hemisphere (Bower & Parsons, 2003). Even though the cerebellum represents only about 10% of total brain volume, it houses more neurons than the rest of the brain combined. For example, the cerebral cortex contains 12 to 15 billion neurons, while the cerebellum contains about 70 billion neurons (Ito, 1984; Williams & Herrup, 1988). Similar to the cerebral cortex, the cerebellum is made up of two hemispheres, which are

connected by a medial grey matter region called the vermis. The cerebellar cortex is made up of Purkinje cells, the principal neurons of the cerebellum, which compose the sole output from the cerebellar cortex. The Purkinje cells also send inhibitory projections to nuclei that are located deep within the hemispheres, which in turn send their output to other brain regions (Eccles, Ito, & Szentagothai, 1967).

The subregions of the cerebellum are classified based on anatomical, phylogenetic, and functional divisions (Allen et al., 2011; Barlow, 2002). In terms of anatomy, the anterior lobe is located above the primary fissure, the posterior lobe is below the primary fissure, and the flocculonodular is inferior to the posterior lobe. Phylogenetically, the archicerebellum (flocculonodular lobe) is the oldest and first to develop, followed by the paleocerebellum (anterior lobe), and lastly the neocerebellum (posterior lobe). Functional areas within the cerebellum correspond to medial-lateral and posterior-anterior divisions. Researchers have localized various functions of the cerebellum, including motor coordination, cognitive functioning, balance and eye tracking. Allen and colleagues (1997) found through functional imaging that the anterior cerebellum is largely responsible for motor tasks, while the posterior cerebellum plays a role in higher order tasks, like selective attention.

The cerebellum also projects to multiple subdivisions of the ventrolateral thalamus, which then project to a multitude of cortical areas, including frontal, prefrontal, and posterior parietal cortex regions (Jones, 1985; Schamahmann, 1996; Strick, Dum, & Fiez, 2009). Therefore, abnormality in the communication among these areas could result in motor deficits, as well as cognitive, affective, and attentional impairments (Strick, Dum,

& Fiez, 2009).

The current study will focus on the vermis and the posterolateral neocerebellar hemispheres (Cerebrocerebellum). The cerebellar vermis will be an area of focus due to its connections to the limbic system (Snider & Maiti, 1976), which have been implicated in previous maltreatment research (De Bellis, et al., 1999; De Bellis, et al., 2000; De Bellis, et al., 2002; Jackowski, et al., 2009; Teicher, et al., 2003; Teicher, Anderson, & Polcari, 2012). The vermis has also been implicated in both animal and human research (Anderson, et al., 2002; De Bellis & Kuchibhatla, 2006; Harlow, Dodsworth, & Harlow, 1965; Maiti & Snider, 1975; Mason & Berkson, 1975; Prescott, 1980).

Since the limbic system has been reported to be negatively affected by maltreatment, it is hypothesized that this impact will be reflected in the cerebellar vermis, given the high level of connectivity between the two structures. It is also hypothesized that the vermis is affected first, given that it undergoes the greatest increase in size of any brain region in the postnatal period (Giedd, et al., 1999) and has the highest density of glucocorticoid receptors (exceeding the hippocampus in the limbic system) (Lawson, et al., 1992). These postnatal developmental aspects of the vermis could make it fairly vulnerable to the effects of stress hormones (Ferguson & Holson, 1999; Schapiro, 1971).

The study will also focus on the cerebrocerebellum, which links the cerebellum to higher-order regions in the brain (Schmahmann, 1996). Specifically there are connections from the cerebrocerebellar circuits that connect to the prefrontal cortex, as well as posterior parietal regions of the brain (Allen et al., 2005; O'Reilly et al., 2010). The posterior regions of the cerebellum are of particular interest, since they are involved

in cognitive and executive functioning. Given that children who experience maltreatment suffer from deficits in executive functioning and cognitive skills, such as planning and emotional regulation (Watts-English, et al., 2006; Wilson, Hansen, & Li, 2011), it is hypothesized that maltreatment impacts the cerebrocerebellum, which then impacts cognitive and executive functioning.

This study will also examine potential sensitive periods of both the vermis and cerebrocerebellum. In a longitudinal MRI cerebellm study, Tiemeier and colleagues (2010) discovered that total cerebellum developed along an inverted U shaped trajectory, which peaked at 11.8 years in females and 15.6 years in males. Furthermore, they found the certain subdivisions of the cerebellum had distinctive developmental trajectory with more phylogenetically recent regions maturing later (Tiemeier, et al., 2010). They also discovered a gender difference in developmental trajectory, particularly in the superior posterior lobe (Tiemeier, et al., 2010). Given the cerebellum's unique developmental trajectories and particular vulnerability to environmental influences, the potential for negatives effects of maltreatment is large.

Cerebellar function. Traditionally the cerebellum was thought to solely control motor coordination. However the idea that the cerebellum only plays a role in motor tasks is becoming an antiquated viewpoint as evidence continues to emerge linking the cerebellum to a myriad of cognitive and emotional tasks.

In a groundbreaking study conducted by Schmahmann and Sherman (1998) of patients with cerebellar lesions helped broaden the field's understanding of cerebellar function. Through this research the term "Cerebellar Cognitive Affective Syndrome"

was coined. The syndrome described a varied host of observed behavioral changes, including flattened affect, behavioral disinhibition, and deficits in set-shifting, planning, visuospatial and language skills (Schmahmann & Sherman, 1998). Schmahmann and Sherman (1998) discovered that lesions found specifically in the vermis and posterior cerebellum (i.e. the area involving cognitive and executive functioning tasks) resulted in distinct behavioral and cognitive changes (previously listed), while lesions in the anterior cerebellum (i.e. the area involving in motor tasks) resulted in minor changes.

These findings have been confirmed by additional studies of patients with cerebellar lesions, resulting in similar deficits, as well as impairments in attention and working memory (Gottwald et al., 2004; Levisohn, Cronin-Golomb, & Schmahmann, 2000; Townsend, et al., 1999). Furthermore, functional neuroimaging studies demonstrate cerebellar activation during non-motor tasks, including but by no means limited to, tasks that involve reasoning and problem solving, attention, and expressive language (Allen, et al., 1997; Desmond, Gabrieli, Wagner, Ginier, & Glover, 1997; Stoodley & Schmahmann, 2009).

While there is growing evidence for cerebellar involvement in a wide range of cognitive and behavioral functions, in addition to motor functions, the exact role of the cerebellum in these various functions remains uncertain. The cerebellum shares widespread anatomical connections to the rest of the brain (i.e. it's large afferent: efferent ratio (40:1) (Allen, et al., 2005). This implies that the cerebellum partakes in a modulating or integrating role of these cognitive, behavioral, and motor functions (Strick, Dum, & Fiez, 2009). In fact, researchers have found evidence that the cerebellum

contributes to higher functions during development, specifically as a modulator of social and mental functions in early childhood (Riva & Giorgi, 2000), with tumors removed from the vermis resulting in two behavioral profiles: one involving speech and language disorders and the other resulting in behavioral disturbances, such as increased irritability (Riva & Giorgi, 2000).

Cerebellar Abnormalities in Maltreatment

Postmortem evidence. Postmortem evidence is limited to animal studies; however, an extensive amount of research has been conducted. Rodents raised in social isolation showed alterations in cerebellum metabolism of serotonin and noradrenaline (Essman, 1968), a significant decrease in ability for benzodiazepine to inhibit the release of neurotransmitters in the cerebellum (Miachon, et al., 1990), delayed formulated of the branch-like ends of dendrites in the cerebellum (Rogers, 1989), and a marked loss of the intracellular calcium-binding protein (calbindin D-28k) to react well to its antigen in the cerebellum (Pascual, et al., 1999).

Monkeys reared in social isolation – experiencing profound emotional neglect - were found to experience emotional dysregulation, extremely elevated levels of aggression, and reduced vermal volume, thus shedding light on the role of the cerebellar vermis in emotional development (Harlow, Dodsworth, & Harlow, 1965; Harlow & Harlow, 1966). Mason and Berkson (1975) discovered that minimal motor interaction with wire mothers (i.e. wire mothers attached to cages in such a way that interaction with the baby allowed the wire mother to move or swing) greatly reduces the severity of negative behaviors observed in isolated primates. This interaction between wire mother

and monkey was hypothesized to stimulate the vestibular nuclei, which is highly connected to the vermis. Thus, the vermis and the vestibular system are believed to be a protective factor against neglect (Berman, 1997; Prescott, 1980).

Furthermore, monkeys reared in isolation demonstrated abnormal EEG activity in the fastigial nucleus – the output nucleus of the vermis, which then projects to the limbic system – and the hippocampus (Cooper & Upton, 1978; Heath, 1972; Heath, 1977; Maiti & Snider, 1975). These findings parallel the research conducted in maltreated children and adults who have abnormal EEG activity (Davies, 1978; Green, et al., 1981; Ito, et al., 1993). The results of these animal studies suggest that the cerebellar vermis is an important region for the maintenance of psychiatric health. They also suggest that the vermis is significantly affected by early stress or neglect, and may have the capacity to reduce or mediate some of the neurological and behavioral consequences of early stress or neglect (Teicher, et al., 2003).

In vivo evidence. De Bellis and Kuchibhatla (2006) were the first to examine cerebellar morphology in adult and child PTSD in maltreated subjects using structural imaging. They examined the cerebellar volume of pediatric victims of maltreatment, suffering from PTSD compared to a non-affected group of children. There were significant group differences in the unadjusted means of the volumetric measures in the right cerebellum, left cerebellum, and whole cerebellum. In comparison to the healthy comparison group, the intracranial volume was 6% and the total cerebellar volume was 7% smaller in the PTSD group. De Bellis and Kuchibhatla (2006) discovered that the longer the child experienced trauma, the smaller the cerebellar volume. Age of onset was

also found to be positively correlated with cerebellar volume. Carrion and colleagues (2009) conducted a prospective study and discovered that children with PTSD had significantly smaller gray matter volume in the posterior vermis. Furthermore, research indicates that maltreated children exhibit deficits in attention (De Bellis, et al., 2009; Schoeman, et al., 2009) greater impulsivity, distractibility, and reduced sustained attention (Beers & De Bellis, 2002), indicating that the cerebellum may be involved in the development of childhood PSTD (Carrion, Wong, & Kletter, 2013).

Carrion and colleagues (2009) conducted a prospective study and discovered that children with PTSD had significantly smaller gray matter volume in the posterior vermis, compared to typical peers. However, the study's inclusion of the vermis was more exploratory and did not go into as much depth of analysis as compared to the study's primary regions of interest. Carrion and colleagues (2009) acknowledged that the study was potentially negatively impacted by its cross-sectional design, the lack of ethnicity and SES matching, as well as only including participants with PTSD.

Bauer and colleagues (2009) studied children raised in orphanages and examined the impact of early deprivation on cerebellar volume and cognitive functioning, discovering that neglected children had smaller volumes of the superior-posterior cerebellar lobes. Furthermore, the superior-posterior cerebellar regions were found to mediate some cognitive processing, specifically planning and visual-spatial memory (Bauer, et al., 2009). The findings suggest an important role of experience-dependent plasticity in the brain-behavior relationship supported by the cerebellum. The fact that postinstitutionalized children demonstrate smaller cerebellar volumes and worse

cognitive performance than typically developing subjects suggests that physiological and social deprivation have a profound influence on cerebellar neurodevelopment. Deprivation serves as an environmental stressor that might disrupt early cerebellar organization and maturation and consequently lead to underdeveloped neural pathways between cerebellum and cortex (Bauer, et al., 2009).

Anderson and colleagues (2002) studied the relationship between cerebellar vermis activity and disturbances in electrical impulses when limbic nerve cells communicate in young adults that experienced childhood maltreatment. While there was no difference in the amount of limbic irritability between the non-affected group and the maltreated group, any amount of limbic symptomatology was linked with significant decrease in perfusion of the vermis in maltreated participants, indicating a marked level of impairment in functioning in cerebellar vermis activity (Anderson, et al., 2002).

In 2010, Anderson and colleagues examined the impact of lingula size of the anterior cerebellar vermis and exposure to maltreatment on alcohol and drug use. The study focused on lingual thickness, in which thick lingual resulted in more empty space in the folds of the cerebellar vermis. Lingula thickness was not found to differ between the maltreatment groups or genders. However, drug use and alcohol use – particularly use of hard liquor – markedly increased with exposure to physical maltreatment, and most prominent in subjects with the thickest linguala (Anderson, et al., 2010). Interestingly, drug use and lingual thickness were not found to correlate with exposure to emotional maltreatment, even though emotional maltreatment was associated with greater symptom ratings of depression (Anderson, et al., 2010). Given the moderate effect of

each of these studies, the emerging interest of the role of the cerebellum in maltreatment, and the implications of diffuse neurological outcomes as a result of altered cerebellar development, further anatomical and functional imaging studies are warranted.

Summary

Childhood maltreatment is a national problem, the prevalence of which is staggeringly high, affecting nearly 50 percent of the population in the United States. Although the full impact of childhood maltreatment has yet to be unveiled, numerous cognitive deficits have been found to be associated with maltreatment. A number of brain structures have also been linked with childhood maltreatment. Most commonly studied brain structures include the hippocampus, the amygdala, and the corpus callosum. While results still vary, it is apparent that experiencing maltreatment in childhood alters the developmental trajectory of the brain.

Older research suggests that the cerebellum is negatively impacted by maltreatment, specifically neglect. With decreased cerebellum size, the animals and humans in these studies also demonstrated a host of emotional issues, some of which resulted in death (Harlow, Dodsworth, & Harlow, 1965). It is only recently that the cerebellum has begun to be studied in connection with human maltreatment. These studies have found that the experience of maltreatment is correlated with smaller cerebellum volumes.

The current study proposes to continue the research of childhood maltreatment and the cerebellum while focusing on a region of the cerebellum that is gaining interest in the maltreatment literature – the cerebrocerebellum. The influence of the type of

maltreatment experienced, the frequency of exposure to maltreatment, and the timing of exposure will be analyzed. Vermal and cerebrocerebellar volume will be examined as part of a large-scale retrospective study, with a total of 600 MRI scans of maltreated and non-affected young adults. The current study predicts cerebellar volume of the maltreated group will differ from the non-affected group, more numerous exposures to maltreatment will result in smaller cerebellar volume within the maltreated group, and different types of maltreatment will have differential effects on cerebellar volume. The current study also predicts that the cerebellum undergoes a sensitive period or "window of vulnerability," in which cerebellar volume is more susceptible to the negative effects of maltreatment.

Chapter Three: Methods

Participants

Data for this study will be collected as part of a larger, ongoing NIH-funded study through the Developmental Biopsychiatry Research Program (DBRP) and Laboratory of Developmental Psychopharmacology at McLean Hospital, a Harvard Medical School Affiliate. Participants are part of various studies investigating sensitive periods of brain development and the development of psychiatric disorders when confronted with exposure to stress during childhood. Recruitment sources for this project include newspaper and Internet advertisements entitled "*Memories of Childhood.*" As part of the project, participants completed multiple screeners, as well as a structured diagnostic interview. Approval by the Institutional Review Board at The Harvard Medical School was previously obtained for the project. Since the data was de-identified before it was shared, the Institutional Review Board at the University of Texas at Austin did not require further review. All participants were given written informed consent via the DBRP website for the collection of their personal information and MRI scans. Participant consent was reviewed as part of the structural interview during the initial meeting.

Participants will be 600 healthy unmediated, right-handed individuals. All participants will be within the ages of 18-25 years, in which about 50% are male. As part of the larger study, participants were selected to provide a balanced sampling of degree of exposure to maltreatment with an approximately equal number of participants having overall MACE scores of 0, 1 ,2 ,3 4 , $\geq$5. Exclusion criteria for the larger study were as follows: history of known neurological disease or insult, head trauma with loss of

consciousness, skull fracture, or any assault above the shoulder; premature birth or birth complications; a history of being shaken as an infant or child, maternal substance abuse during pregnancy, or medical disorders that could impact brain development. Participants must not have utilized alcohol, illicit drugs, or medications for at least two weeks prior to enrollment. Participants that do not meet safety criteria to undergo an MRI scan will be excluded to maintain image quality and the safety of the participants. In addition, participants who had contradictions to the MRI procedure, such as pacemakers and surgical clips, were excluded.

For the current study, there will be approximately 600 participants, with 280 maltreated participants and 320 control subjects. All participants completed the MACE measure and structural MRI. Participant racial, ethnic, and socioeconomic group status information will be available for all participants.

Instrumentation

Participants were administered a number of measures as part of the larger DBRP study. However, for the purposes of this study only the Maltreatment and Abuse Chronology of Exposure scale (MACE) and a demographic information form will be used. Participants will also complete structural brain imaging scans.

Maltreatment and Abuse Chronology of Exposure scale (MACE) (Teicher & Parigger, unpublished). The MACE is a self-report questionnaire designed to retrospectively assess different forms of abuse, neglect, household dysfunction, peer victimization, witnessing domestic violence, and self experienced abuse or neglect. In total, the MACE assesses ten different categories of maltreatment. The MACE also

gathers information on the magnitude of the experienced adversities, as well as emotional reactions to events and temporal anchoring of the event. The MACE demonstrates excellent test-retest reliability across all ages ($r = 0.894$, $n = 60$) by comparing severity scores for each subject on test versus retest. The MACE also show good convergent validity as the instrument correlated 0.741 (95% CI = 0.697-0.780, $t = 23.74$, $df = 462$, $p < 10\text{-}16$) with the Childhood Trauma Questionnaire (CTQ), a measure commonly used in the maltreatment literature (Pechtel, et al., 2014). The MACE also demonstrated good convergent reliability with Adverse Childhood Experiences (ACE) scores (95% CI = 0.677-0.731, $t = 26.21$, $df = 1323$, $p<10\text{-}16$) (Pechtel, et al., 2014). However, on average, MACE scores accounted for 2.28-fold and 2.04 fold more of the variance in symptoms ratings (i.e. depression, anxiety, somatization, anger-hostility, dissociation, and suicidal ideation) that CTQ and ACE scores (Pechtel, et al., 2014).

Data Acquisition of Magnetic Resonance Images

Images were acquired at the McLean Hospital Brian Imaging Center using a Siemens 3-T TIM Trio scanner with a 32-channel head coil using a T1-weighted Magnetization Prepared Rapid Gradient Echo (MPRAGE) pulse sequence (TE: 2.25 ms; TR: 2100 ms; FA = 12; FOV: 256 mm; slice number: 128; voxel size: 1.0 x 1.0 x 1.3 mm; slice thickness: 1.33 mm) in the sagittal plane (scan duration: 6 min). T2-weighted matched TSE images were used to aid region of interest (ROI) definition (TE/TR = 90 ms/4.5 s; matrix 384 x 384 on (220 mm)squared FOV; 26 x 5 mm slices with no gap; GRAPPA, two averages, with a reduced refocus pulse of 150 degrees (BW 99 Hz/pixel = 38 kHz, turbo factor = 9; 17.1 esp).

Image Processing

Intracranial Volume. Measures of intracranial volume will be obtained to control for potential differences in overall brain size. An MRI technician trained in image processing will obtain intracranial volume data using the Freesurfer Program. The procedure is based on Buckner and colleagues' method (2004), which uses an atlas-based spatial normalization procedure. The Buckner et al. (2004) template is an averaged image created from 24 healthy young and old adults, using Talairach and Tournoux's (1988) atlas as a guide.

To obtain intracranial volume, each individual's brain scan will be registered to the atlas template using a single affine transformation. The skull and extracranial matter will be removed using thresholding and manual tracing. Then, a semi-automatic quantification tool within Freesurfer will be used to obtain the intracranial volume measurements.

Cerebellar Volume Measurement. Image analysis will be performed using Analyze software (11.0; Build ADS-0442, Mayo Foundation, Rochester, Minnesota) running in a Unix environment of an iMac computer. Analyze 9.0 has registration, visualization, tracing, and classification features that allow for accurate quantification of structural data. The software allows tracing in the sagittal, axial, and coronal planes, and cross-sections of the traces can be viewed in orthogonal planes to ensure measurement precision. Tracing will be completed by graduate students who have previously achieved inter-rater reliability scores of r=.90 or higher on training samples. In order to ensure that

raters remain blind to the classification of the participants (i.e. maltreatment or non-affected participants), the scans will be de-identified and numerically coded.

The cerebellum will be manually traced on the high-resolution T1-weighted images in the Analyze Region of Interest (ROI) module and saved using the Object Map function. The traced region will not include cerebrospinal fluid (CSF) and non-brain tissue (i.e., blood vessels, dura mater, etc.). Tracing will be performed mainly in the coronal plane, and edits will be made in the axial and sagittal planes. Region identification will be guided by established atlases of the human cerebellum (Schmahmann, Doyon, Toga, Evans, & Petrides, 2000). The boundary between the cerebellar peduncle and cerebellar interior white matter will be traced according to the procedures described by Pierson and colleagues (2002). The cerebellar peduncles will be separated from the cerebellar interior white matter by marking a straight line from the most antero-lateral portion of the fourth ventricle to the edge of the brainstem-cerebellum junction. The polygon tool will be used to draw straight lines of this boundary in the axial plane.

Anatomical quantification of cerebellar sub regions. Cerebellar gray matter will be divided into the vermis and hemispheres lobules. Tracing of these subregions will be conducted manually in the coronal plane. Atlases of the human cerebellum will guide the region identification (Schmahmann, Doyon, Toga, Evans, & Petrides, 2000). The segmentation of regions employed is based on cerebellar parcellation approaches previously utilized in the literature (Allen, Muller, & Courchesne, 2004; Makris, et al., 2005; Pierson, et al., 2002).

The current study will focus on the cerebellar vermis and the cerebrocerebellum. Tracing these regions will be guided by fissure boundaries. Specifically, the posterior region of the cerebellum consists of lobules VI through X. The posterior region is inferior to the primary fissure, the boundary between lobule V and VI. The primary fissure distinguishes the anterior region from the posterior region of the cerebellum. The cerebellar vermis will be defined using standard anatomical landmarks (Schmahmann, et al., 1999). The volume of the gray matter (in mm^3) of each subregion will be calculated using the Sampling Regions tool within the ROI module. The total gray matter volume of each region will be totaled and entered into analysis. Next, the regions of interest will be traced on every seventh slice in the sagittal view and then automatically propagated to the remaining slices. The posterior cerebellum and the vermis will then saved as an object within the object map function. Following this step, a semi-automatic tool will be used to differentiate between white and gray matter in the posterior cerebellum within the coronal view. Each trace will then be checked for errors prior to quantification. Volumetric measurements will be calculated (in mm^3) automatically using the Sample Regions feature in the ROI module. Volumes of the gray and white matter of the posterior cerebellum and the vermis will be obtained.

Analyses

The primary purposes of this study are (1) to examine the predictive relationship of exposure to maltreatment and vermal and cerebrocerebellar volume in maltreated participants and control participants, (2) to examine the predictive relationship of type, timing, and frequency of exposure to maltreatment and vermal and cerebrocerebellar

volume among maltreated participants, and (3) to examine the interaction effects of gender and type and age of maltreatment on vermal and cerebrocerebellar volume in maltreated participants. Random forest regression analyses will be used to test the hypotheses.

Descriptive analyses. R statistical software will be used to analyze data. Descriptive statistics will be computed for predictor and outcome variables. Descriptive statistics, including means, standard deviations, ranges, and minimum and maximum values will be analyzed for each continuous variable. Variables will be checked for normality and outliers. Assumptions for each analysis will be examined. Normal distribution of residuals will be confirmed using a residual and predicted value plot. Data will also be tested for multicollinearity. Tolerance will be set at .14 and a VIF of 7 will be used to assess for excessive multicollinearity (Cohen, et al., 2003).

All four demographic variables – gender, age, socioeconomic status, and ethnicity – will be analyzed in every hypothesis. Gender will be dichotomized. Age will be viewed as a continuous variable. SES will be divided into three categorical variables (low, middle, and upper) and ethnicity will be divided into five categorical variables (Caucasian, African American, Latino, Asian/Pacific Islanders, Other). Tests will be conducted to determine if there are statistically significant differences between males and females. While outliers may be present, extreme values of cerebellar volume are of particular interest to the research question, and thus will likely not be discarded from the sample.

Power analyses. Traditionally, power analyses are conducted using G*POWER software. However, G*POWER does not allow for a power analysis to be conducted for a random forest regression. Research indicates that random forest regression is quite robust against overfitting and provides very high accuracy (Breiman, 2001). An a priori power analysis was conducted as if a multiple regression would be run with 36 identified predictor variables. The analysis determined that 280 participants were needed given the chosen effect size, power, and alpha parameters to obtain significant results (*d*: 0.15, β = .80; α = .05). While this analysis is not necessarily application to the random forest regression, it enables an examination o the potential power present with the number of predictor variables and the given sample size.

Preliminary analyses. Cerebellar regions will be centered and scaled for each region to provide an arbitrary mean of 100 and standard deviation of 10, to facilitate comparison between regions and various predictors, such as importance of age of exposure using the increase in MSE criteria.

Random forest regression analyses. Breiman (2000) defined a random forest as a "classifier consisting of a collection of tree- structured classifiers {h(x,Θk), k=1, ...} where the {Θk} are independent identically distributed random vectors and each tree casts a unit vote for the most popular class at input x." Simply put, random forest regression generates a collection of small, unpruned decision trees, then aggregates the results. Each tree is generated using a different bootstrap sample of the data, and each node is split based on the best subset of predictors (Brieman, 2001; Garcia-Magarinos, et al., 2009).

Random forest regression is a novel method for determining variable importance, can model complex interactions among predictor variables, has high classification accuracy, and can utilize an algorithm for imputing missing values (Cutler, et al., 2007; Teicher, et al., 2013). For example, the 'randomForest' package in R replaces missing numeric variables with column medians and replaces missing factor variables with the most frequent levels, breaking ties at random (Breiman, et al., 2014).

In order for the "out-of-bag" (OOB) error rate to stabilize, a sufficient number of trees needs to be chosen. Research indicates that 500 trees are sufficient to stabilize OOB error (Svetnik, et al., 2003). Therefore 500 trees will be generated in the initial analysis, and then the error rate will be assessed to determine if more trees are warranted. The performance and accuracy of random forest regression changes only near the extremes, thus enabling a larger number of descriptors or variables to be studied without compromising the validity of the results (Svetnik, et al., 2003).

Error Analysis. In order to test for error, about one-third of the testing sample will be left out and analyzed separately. This data, named "out-of-bag" or OOB data will be used as an internal test set for each tree that it grown. The OOB predictions will then be aggregated and the error rate will be computed for the whole forest, which should lead to an accurate and unbiased generalization error (Brieman, 2001; Robert-Granie, Cao, & SanCristobal, 2009). Random forest regression does not require further cross-validation (Svetnik, et al., 2003).

Analysis of Variable Importance. Mean squared errors (MSE) will be calculated to provide estimates of the importance of each of the variables. The MSE is

calculated using two measures. The first measure is computed from permuting OOB data: For each tree, the prediction error on the out-of-bag portion of the data is recorded (i.e. MSE). The same is done after permuting each predictor variable. The difference between the two are then averaged over all trees, and normalized by the standard deviation of the differences (Breiman, et al., 2014). The second measure is the total decrease in node impurities from splitting on the variable, averaged over all trees (which for regression, it is measured by residual sum of squares) (Breiman, et al., 2014).

In summary, the MSE is calculated using the OOB predictions, and in each OBB set, the descriptors are individually scrambled and predictions are made. The difference between these two values provides the MSE (Guha & Jurs, 2004). Variable importance, based on permutations (i.e. rearranging predictors variables of a set into a particular sequence), will then be converted to z-scores to determine levels of significance (Teicher, et al., 2013). In general, permutation of important predictor variables produces a large increase in MSE, whereas permutation of unimportant predictors produces little or no increase in MSE (Teicher, et al., 2013).

Tests of Research Hypotheses

Hypothesis 1. Exposure to childhood maltreatment will predict smaller cerebellar vermis and cerebrocerebellum volumes in young adults with self-reported histories of childhood maltreatment as compared to typical young adults.

Random forest regression analysis will examine the predictive utility of exposure to childhood maltreatment in predicting reduced vermal and cerebrocerebellar volume.

The cerebellum undergoes an enormous postnatal period of growth and development and is particularly susceptible to environmental influences. Given the cerebellum's sensitivity and postnatal growth, the current hypothesis expects differences between the maltreated and control group in cerebellar volume to be present on the MRI scans.

Hypothesis 2. Type, timing, and frequency of maltreatment will predict cerebellar morphology in young adults with self-reported histories of childhood maltreatment. Specific "windows of vulnerability" or developmental sensitive periods when exposed to specific types of maltreatment will have the strongest statistical effect ($p<0.05$) of vermal and cerebrocerebellar volume.

Random forest regression analysis will examine the predictive utility of the type, timing, and frequency of maltreatment on vermal and cerebrocerebellar volume of maltreated individuals.

Hypothesis 2a – Type of Maltreatment*:* Studies focusing on the behavioral outcomes of experiencing maltreatment have discovered that different types of maltreatment result in different outcomes (Cicchetti & Toth, 2005). More importantly are the discoveries that specific types of abuse tend to result in more intense outcomes.

Hypothesis 2b – Timing of Maltreatment*:* Tiemeier and colleagues (2010) discovered that the cerebellum develops along an inverted U-shaped trajectory. Furthermore, results indicate that cerebellar development peaked in females at an earlier age compared to males and certain areas of the cerebellum developed and different ages for males and females (Tiemeier, et al., 2010).

Hypothesis 2c – Frequency of Maltreatment Experienced*:* Research also indicates that more frequent exposure to maltreatment results in poorer health outcomes (Felitti, et al., 1998). Given the results of the existing literature, it is hypothesized that vermal and cerebrocerebellar volume will be statistically significantly differentially impacted based on the timing, type, and frequency of maltreatment experienced.

Hypothesis 3. Type of maltreatment will predict different cerebellar morphology according the gender on young adults with self-reported histories of childhood maltreatment.

Random forest regression analysis will examine the predictive utility of the type of maltreatment on vermal and cerebrocerebellar volume of maltreated individuals based on gender. In certain brain structures, research indicates that males tend to be more negatively affected by neglect, whereas females are more negatively impacted after experiencing sexual abuse (Teicher, et al., 2000; Teicher, et al., 2004). Specifically, girls showed smaller corpus callosum size and hippocampal volume after experiencing sexual abuse, whereas boys experienced smaller corpus callosum size and hippocampal volume after experiencing neglect (Teicher, et al., 2000, Teicher, et al., 2004). It is therefore hypothesized that vermal and cerebrocerebellar volume will be statistically different in males and females based on the type of abuse experienced.

Hypothesis 4. Timing of maltreatment will predict different cerebellar morphology according the gender on young adults with self-reported histories of childhood maltreatment.

Random forest regression analysis will examine the predictive utility of the timing of maltreatment on vermal and cerebrocerebellar volume of maltreated individuals based on gender. Children also undergo different rates of hippocampal myelination, depending on their gender and age. Teicher and colleagues (2004) noted that reduced myelination is more likely to occur sooner for boys and later for girls, which corresponds to the differential findings in the hippocampus due to the fact that boys tend to experience neglect earlier and girls experience sexual abuse later in life. The cerebellum is hypothesized to be similarly affected given that like the hippocampus, the cerebellum may produce granule cells postnatally and has the highest density of glucocorticoid receptors during development (actually exceeding that of the hippocampus) (Altman & Bayer, 1997; Lawson, et al., 1992). Furthermore, the ongoing postnatal growth of the cerebellum make the cerebellum particular vulnerable to stress (Ferguson & Holson, 1999; Schapiro, 1971). Therefore, it is hypothesized that timing of maltreatment will impact the development of the cerebellum, depending on gender.

Appendix A

MACE Scale (Teicher, M. H., & Parigger, A., 2011, used with permission)

Sometimes parents, stepparents or other adults living in the house do hurtful things.
If this happened during your childhood (first 18 years of your life) please provide your best estimate of your age at the time(s) of occurrence.
Please check all ages that apply.

For example item 1. Swore at you, called you names, said insulting things like your "fat", "ugly", "stupid", etc. more than a few times a year.

If at ages 6-8 your father swore at you and at ages 8-10 your mother insulted you, and at age 17 your mother's new live-in boyfriend called you names; you would check off as follows:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
					✓	✓	✓	✓	✓							✓	

● Yes ○ No

1. Swore at you, called you names, said insulting things like your "fat", "ugly", "stupid", etc. more than a few times a year.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

○ Yes_1 ○ No_0

2. Said hurtful things that made you feel bad, embarrassed or humiliated more than a few times a year.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

○ Yes_1 ○ No_0

3. Yelled or screamed at you more than a few times per year.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

○ Yes_1 ○ No_0

4. Acted in a way that made you afraid that you might be physically hurt.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

○ Yes_1 ○ No_0

Please indicate if this made you feel helpless or terrified.

❒ Helpless ❒ Terrified

5. Threatened to leave or abandon you.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

○ Yes_1 ○ No_0

Please indicate if this made you feel helpless or terrified.

❒ Helpless ❒ Terrified

6. Locked you in a closet, attic, basement or garage.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$ ❍ No$_0$ ❍
Helpless ❐ Terrified ❐

7. Intentionally pushed, grabbed, shoved, slapped, pinched, punched or kicked you.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$ ❍ No$_0$ ❍
Helpless ❐ Terrified ❐

8. Hit you so hard that it left marks for more than a few minutes.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$ ❍ No$_0$ ❍
Helpless ❐ Terrified ❐

9. Hit you so hard, or intentionally harmed you in some way, that you received or should have received medical attention.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$ ❍ No$_0$ ❍
Helpless ❐ Terrified ❐

10. Spanked you with their open hand on your buttocks, arms or legs.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$ ❍ No$_0$ ❍
Helpless ❐ Terrified ❐

11. Spanked you on your bare (unclothed) buttocks.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$ ❍ No$_0$ ❍
Helpless ❐ Terrified ❐

12. Spanked you with an object such as a strap, belt, brush, paddle, rod, etc.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$ ❍ No$_0$ ❍
Helpless ❐ Terrified ❐

13. Made inappropriate sexual comments or suggestions to you.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

❍ Yes$_1$

❒ Helpless

14. Touched or fondled your body in a sexual way.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

❍ Yes$_1$ ❍ No$_0$

❒ Helpless ❒ Terrified

15. Had you touch their body in a sexual way.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

❍ Yes$_1$ ❍ No$_0$

❒ Helpless ❒ Terrified

16. Attempted to have any type of sexual intercourse (oral, anal or vaginal) with you.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

❍ Yes$_1$ ❍ No$_0$

❒ Helpless ❒ Terrified

17. Actually had any type of sexual intercourse (oral, anal or vaginal) with you.
Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

❍ Yes$_1$ ❍ No$_0$

❒ Helpless ❒ Terrified

Sometimes parents, stepparents or other adults living in the house do hurtful things to your siblings (brother, sister, stepsiblings).
If this happened during your childhood (first 18 years of your life) please provide your best estimates of your age at the time(s) of occurrence.
Please check all ages that apply.

18. Intentionally pushed, grabbed, shoved, slapped, pinched, punched, or kicked your sibling (stepsibling).

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$	No$_0$
❍	❍
❐ Helpless	❐ Terrified

19. Hit your sibling (stepsibling) so hard that it left marks for more than a few minutes.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$	No$_0$
❍	❍
❐ Helpless	❐ Terrified

20. Hit your sibling (stepsibling) so hard, or intentionally harmed him/her in some way, that he/she received or should have received medical attention.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$	No$_0$
❍	❍
❐ Helpless	❐ Terrified

21. Made inappropriate sexual comments or suggestions to your sibling (stepsibling).

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$	No$_0$
❍	❍
❐ Helpless	❐ Terrified

22. Touched or fondled your sibling (stepsibling) in a sexual way.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$	No$_0$
❍	❍
❐ Helpless	❐ Terrified

23. Had your sibling (stepsibling) touch their body in a sexual way.

❍	❍

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$	No$_0$
❐	❐
Helpless	Terrified

24. Had or attempted to have any type of sexual intercourse (oral, anal or vaginal) with your sibling (stepsibling).

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

❍	❍
Yes$_1$	No$_0$
❐	❐
Helpless	Terrified

25. Threatened to harm your sibling (stepsibling).

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

❍	❍
Yes$_1$	No$_0$
❐	❐
Helpless	Terrified

Sometimes adults or older individuals NOT living in the house do hurtful things to you.
If this happened during your childhood (first 18 years of your life) please provide your best estimates of your age at the time(s) of occurrence.
Please check all ages that apply.

26. Made inappropriate sexual comments or suggestions to you.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

❍	❍
Yes$_1$	No$_0$
❐	❐
Helpless	Terrified

27. Touched or fondled your body in a sexual way.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

❍	❍
Yes$_1$	No$_0$
❐	❐
Helpless	Terrified

28. Had you touch their body in a sexual way.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

❍	❍
Yes$_1$	No$_0$
❐	❐
Helpless	Terrified

29. Attempted to have any type of sexual intercourse (oral, anal or vaginal) with you.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$	No$_0$
❍	❍
❒	❒
Helpless	Terrified

30. Actually had sexual intercourse (oral, anal or vaginal) with you.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$	No$_0$
❍	❍
❒	❒
Helpless	Terrified

Sometimes intense arguments or physical fights occur between parents, stepparents or other adults (boyfriends, girlfriends, grandparents) living in the household.
If this happened during your childhood (first 18 years of your life) please provide your best estimates of your age at the time(s) of occurrence.
Please check all ages that apply.

31. Witnessed adults living in the household argue intensely with your mother (stepmother, grandmother), say derogatory things to her, or threaten her with harm.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$	No$_0$
❍	❍
❒	❒
Helpless	Terrified

32. Witnessed adults living in the household argue intensely with your father (stepfather, grandfather), say derogatory things to him, or threaten him with harm.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$	No$_0$
❍	❍
❒	❒
Helpless	Terrified

33. Saw adults living in the household push, grab, slap or throw something at your mother (stepmother, grandmother).

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if this made you feel helpless or terrified.

Yes$_1$	No$_0$
❍	❍
❒	❒
Helpless	Terrified

34. Saw adults living in the household hit your mother (stepmother, grandmother) so hard that it left marks for more than a few minutes.

Please check all ages that apply.

Yes$_1$	No$_0$
❍	❍

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❒ Helpless ❒ Terrified

Please indicate if this made you feel helpless or terrified.

35. Saw adults living in the household hit your mother (stepmother, grandmother) so hard, or intentionally harm her in some way, that she received or should have received medical attention.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❒ Helpless ❒ Terrified

Please indicate if this made you feel helpless or terrified.

36. Saw adults living in the household push, grab, slap or throw something at your father (stepfather, grandfather).

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❒ Helpless ❒ Terrified

Please indicate if this made you feel helpless or terrified.

37. Saw adults living in the household hit your father (stepfather, grandfather) so hard that it left marks for more than a few minutes.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❒ Helpless ❒ Terrified

Please indicate if this made you feel helpless or terrified.

38. Saw adults living in the household hit your father (stepfather, grandfather) so hard, or intentionally harm him in some way, that he received or should have received medical attention.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❒ Helpless ❒ Terrified

Please indicate if this made you feel helpless or terrified.

Sometimes children your own age or older do hurtful things like bully or harass you.
If this happened during your childhood (first 18 years of your life) please provide your best estimates of your age at the time(s) of occurrence.
Please check all ages that apply.

39. Swore at you, called you names, said insulting things like your "fat", "ugly", "stupid", etc. more than a few times a year.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate ages when (if) the person doing this to you was a date (e.g., boyfriend, girlfriend, someone you associated with on a social, romantic or intimate level).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❍ Yes$_1$ ❍ No$_0$

❍ Yes$_1$ ❍ No$_0$

40. Said hurtful things that made you feel bad, embarrassed or humiliated more than a few times a year.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate ages when (if) the person doing this to you was a date.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❍ Yes$_1$ ❍ No$_0$

❍ Yes$_1$ ❍ No$_0$

41. Said things behind your back, posted derogatory messages about you, or spread rumors about you.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate ages when (if) the person doing this to you was a date.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❍ Yes$_1$ ❍ No$_0$

❍ Yes$_1$ ❍ No$_0$

42. Intentionally excluded you from activities or groups.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate ages when (if) the person doing this to you was a date.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❍ Yes$_1$ ❍ No$_0$

❍ Yes$_1$ ❍ No$_0$

43. Acted in a way that made you afraid that you might be physically hurt.

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate ages when (if) the person doing this to you was a date.

❍ Yes$_1$ ❍ No$_0$

❍ Yes$_1$ ❍ No$_0$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Yes$_1$	No$_0$

44. Threatened you in order to take your money or possessions. ❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate ages when (if) the person doing this to you was a date. ❍ Yes$_1$ ❍ No$_0$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

45. Forced or threatened you to do things that you did not want to do. ❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

If yes, please describe examples:

Please indicate ages when (if) the person doing this to you was a date. ❍ Yes$_1$ ❍ No$_0$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

46. Intentionally pushed, grabbed, shoved, slapped, pinched, punched, or kicked you. ❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate ages when (if) the person doing this to you was a date. ❍ Yes$_1$ ❍ No$_0$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

47. Hit you so hard that it left marks for more than a few minutes. ❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate ages when (if) the person doing this to you was a date. ❍ Yes$_1$ ❍ No$_0$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

48. Hit you so hard, or intentionally harmed you in some way, that you received or should have received medical attention.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate ages when (if) the person doing this to you was a date.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❍ Yes$_1$ ❍ No$_0$

49. Forced you to engage in sexual activity against your will.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate ages when (if) the person doing this to you was a date.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❍ Yes$_1$ ❍ No$_0$

50. Forced you to do things sexually that you did not want to do.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate ages when (if) the person doing this to you was a date.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

❍ Yes$_1$ ❍ No$_0$

Please indicate if the following happened during your childhood (first 18 years of your life). Please provide your best estimates of your age at the time(s) of occurrence.

Please check all ages that apply.

51. You felt that your mother or other important maternal figure was present in the household but emotionally unavailable to you for a variety of reasons like drugs, alcohol, workaholic, having an affair, heedlessly pursuing their own goals.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

52. You felt that your father or other important paternal figure was present in the household but emotionally unavailable to you for a variety of reasons like drugs, alcohol, workaholic, having an affair, heedlessly pursuing their own goals.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

53. You felt that your mother or other important maternal figure was emotionally unavailable to you for a variety of reasons like military service, taking care of a sick relative, in school, business necessity.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

54. You felt that your father or other important paternal figure was emotionally unavailable to you for a variety of reasons like military service, taking care of a sick relative, in school, business necessity.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

55. A parent or other important parental figure was very difficult to please.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

56. A parent or other important parental figure did not have the time or interest to talk to you.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

57. One or more individuals in your family made you feel loved.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Who? (e.g. mother, aunt, maternal grandfather)

58. One or more individuals in your family helped you feel important or special.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Who? (e.g. mother, aunt, maternal grandfather)

59. One or more individuals in your family were there to take care of you and protect you.

❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Who? (e.g. mother, aunt, maternal grandfather)

60. One or more individuals in your family were there to take you to the doctor or Emergency Room if the need ever arose. ❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Who? (e.g. mother, aunt, maternal grandfather)

61. One or more individuals in your family would help you with your homework, or to get ready for school. ❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Please indicate if the following statements were true about you and your family during your childhood, and your age at the time(s) you felt this to be true.

Please check all ages that apply.

62. You didn't have enough to eat. ❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

63. You had to wear dirty clothes. ❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

64. You were left unsupervised at an age or in situations when you should have been supervised. ❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

65. You felt that you had to shoulder adult responsibilities. ❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

66. You felt that your family was under severe financial pressure. ❍ Yes$_1$ ❍ No$_0$

Please check all ages that apply.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

67.	One or more individuals kept important secrets or facts from you. Please check all ages that apply. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	❍ Yes$_1$	❍ No$_0$
68.	Your parents were separated. Please check all ages that apply. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	❍ Yes$_1$	❍ No$_0$
69.	Your parents were divorced. Please check all ages that apply. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	❍ Yes$_1$	❍ No$_0$
70.	A parent or other important parental figure died. Please check all ages that apply. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	❍ Yes$_1$	❍ No$_0$
71.	You had to spend time living in two or more households. Please check all ages that apply. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	❍ Yes$_1$	❍ No$_0$
72.	You lived in foster care. Please check all ages that apply. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	❍ Yes$_1$	❍ No$_0$
73.	People in your family looked out for each other. Please check all ages that apply. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	❍ Yes$_1$	❍ No$_0$
74.	People in your family felt close to each other. Please check all ages that apply. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	❍ Yes$_1$	❍ No$_0$
75.	Your family was a source of strength and support. Please check all ages that apply. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	❍ Yes$_1$	❍ No$_0$

Appendix B

Demographic Information Form

Ethnic Background

Please check one *:

☐ Hispanic or Latino
☐ Not Hispanic or Latino

Racial Background

Please check any that apply *:

☐ American Indian/Alaska Native
☐ Asian
☐ Native Hawaiian or Other Pacific Islander
☐ Black or African American
☐ White
☐ Other

Please complete the following:

☐ Age *:
☐ IQ:
☐ How many full siblings do you have? *:
☐ How many step or half siblings did you have living with you while you grew up? *:
☐ SAT Score Entering College *
☐ Math Score *
☐ Verbal Score *
☐ College GPA:

Education Information

Please check off the highest level of education achieved.

Your Education*

Total number of years of education beginning with 1st Grade :
☐ High School Graduate (or the equivalent, for example GED)
☐ Associate Degree
☐ Bachelor's Degree (for example BA, BS, AB)
☐ Master's Degree (for example, MA, MS, MEng, MEd, MSW, MBA)
☐ Professional School Degree (for example, MD, DDS, DVM, JD)
☐ Doctoral Degree (for example, PhD, EdD)

Father's Education*:

Total number of years of education beginning with 1st Grade :
☐ High School Graduate (or the equivalent, for example GED)
☐ Associate Degree
☐ Bachelor's Degree (for example BA, BS, AB)
☐ Master's Degree (for example, MA, MS, MEng, MEd, MSW, MBA)
☐ Professional School Degree (for example, MD, DDS, DVM, JD)
☐ Doctoral Degree (for example, PhD, EdD)

Father's Occupation:

Mother's Education*:

Total number of years of education beginning with 1st Grade :
☐ High School Graduate (or the equivalent, for example GED)
☐ Associate Degree
☐ Bachelor's Degree (for example BA, BS, AB)
☐ Master's Degree (for example, MA, MS, MEng, MEd, MSW, MBA)
☐ Professional School Degree (for example, MD, DDS, DVM, JD)
☐ Doctoral Degree (for example, PhD, EdD)
Mother's Occupation:

Family Economic Information

Which statement describes your family financial situation when you were a **child***:

☐much less than enough money for our needs
☐less than enough money for our needs
☐enough money for our needs
☐more than enough money for our needs
☐much more than enough money for our needs

Current Family Income*:

☐0 to $15,000
☐$16,000 to $25,000
☐$26,000 to $50,000
☐$51,000 to $75,000
☐$76,000 to $100,000
☐$101,000 to $150,000
☐$151,000 to $200,000
☐$201,000 or more

Medical History Information

Have you ever smoked cigarettes regularly?
Approximate number of cigarettes per day?
Age you first smoked?
Age you last smoked?
Do you smoke cigarettes now? *
Have you ever attempted to quit smoking cigarettes? *
If yes, how many times have you attempted to quit?
Have you ever been diagnosed with attention deficit problems (ADD or ADHD)? *
Were you ever treated with medications for ADD or ADHD?
Age first medicated for ADD or ADHD
Age last medicated for ADD or ADHD
Name of medication(s) used for treatment

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